

1 number of good points and I'll try to be very
2 brief, but we talked a lot today about the problem
3 of incumbents opposing change for economic self-
4 interest reasons. Part of the irony is that their
5 economic interest is not properly defined. Part of
6 the problem with narrow definitions, we don't have
7 this so much in PCS anymore, but in the traditional
8 use is that in one sense the licensee views the
9 opportunity costs of the spectrum as zero. To
10 society, we know it's quite high, but their choice
11 is I use it for this narrow purpose or I turn it
12 back to the government. Well, you can imagine then
13 that inefficient uses endure long beyond new
14 technologies and so on. Now if you move
15 flexibility in place and that's why flexibility has
16 become more and more a part of the Commission's
17 allocation process, then suddenly the opportunity
18 costs becomes much larger. Now the PCS operator
19 thinks about new technologies, thinks about new
20 uses and now let's transfer this to UHF television.
21 I'm just going to throw this out for illustration
22 purposes. What if the Commission initially created
23 on the 400 megahertz of UHF television 10 40
24 megahertz nationwide assignments and said okay, and
25 said okay, we'll have four 10 UHF broadcasters.

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1 Initially, we would have had probably something
2 closer to 10 networks and they would have made all
3 of the internal co-channel and adjacent channel two
4 boot decisions themselves and they would have been
5 internalized and then guess what? Ten years later
6 we decide, let's put flexibility in place on these
7 guys and suddenly they decide that they want to do
8 PCS, okay? And that's what we're talking about
9 here. We need to put in place incentives that
10 channel market forces to move new technology and
11 new uses in place and it isn't just new
12 technologies. It's new uses as well. And people,
13 and Victor makes a good point. I mean you can't
14 look at bits per hertz per second or whatever.
15 Bits value are valued differently. Hertz are
16 valued differently and so it's a very complicated
17 process.

18 DR. KOLODZY: Questions?

19 MR. SNYDER: I'd like to respond to Ed
20 Thomas' inquiry about the policy implications of
21 software-defined radio. I think one of the most
22 important implications is it creates the
23 possibility of having micro licenses. Until now,
24 the FCC has generalized licensed in terms of years
25 or even decades and I think the underlying economic

1 reason why that made sense as because of high acid
2 specificity. If you're going to invest a lot of
3 money in the business, you need to get a return.
4 But that whole logic changes with software-defined
5 radio and a lot of the talk on software-defined
6 radio focuses on the receivers rather than the
7 transmitters, but you can have flexibility on the
8 transmitter side as well.

9 So I guess my question here is what do
10 you think about micro licenses? You can imagine
11 that any incumbent would utterly hate the idea of
12 micro licenses because in effect you're saying
13 well, you're going to buy your license on the free
14 market. I'm talking about a minute by minute
15 license possibly, geographically flexible. It's
16 essentially like saying I'm going to take your
17 license away. We're not moving necessarily to an
18 unlicensed regime --

19 MS. RATH: Just a little clarification.
20 Who's actually selling the licenses or is it the
21 FCC distributing it or -- how do you determine
22 that?

23 MR. SNYDER: Well, it could be through
24 the private market. I would suggest that the FCC
25 become an information broker. Instead of making

1 these licensing decisions so rarely, it doesn't --
2 in a free market environment, it becomes an
3 information broker of licenses, so the FCC
4 distributes micro licenses minute by minute on a
5 bit basis. There are a lot of ideas like this out
6 there, but we separate the equipment business from
7 the ownership of spectrum. And you can imagine why
8 incumbents would dislike micro licenses. So I
9 think that's a major implication. This is not an
10 unlicensed idea, but it's sort of neither the
11 traditional licensing or a license -- we're here
12 talking about what does the license of the future
13 look like? We talk a lot about interference rights
14 and what not. We're not talking about the time and
15 duration and other things which become possible in
16 the new era.

17 DR. KOLODZY: Next comment? Any other
18 questions?

19 Steve, I'm sorry?

20 MR. SNYDER: I wanted to ask your
21 opinion of micro licenses, if anybody --

22 DR. KOLODZY: I'm sorry.

23 MR. SHARKEY: I was actually going to
24 address that. I was going to come back to this,
25 but I mean innovative ways to do licensing, I

1 think, is good. I mean the technology is there to
2 do that type of thing. I think that's good. But
3 on the economic model, there are a lot of things
4 that I think that you can do to encourage the
5 innovation and a lot of ways to encourage it. I
6 think economics is a great way to do it. And there
7 are a lot of like four in the PCS band, I think
8 they've got a lot of economic incentives. I mean
9 there are some -- the spectrum has been auctioned.

10 Not that we're for trends of auctions and what
11 that does to the cost of spectrum, but that's a
12 real economic driver for making efficient use of
13 that. I think applying some sort of economic model
14 across the board to -- and more evenly across the
15 spectrum that's used, whether it's federal
16 government, commercial or other licensees is a good
17 way to help drive up that. And the other side is,
18 I think some of the things that Peter's talking
19 about too, the carrot of providing incentives to
20 licensees to be allowed to trade spectrum or
21 licenses so that it is -- they realize some
22 economic gain when they do that.

23 But you brought up the consideration of
24 infrastructure too. I think that there is a role
25 sometimes for the FCC to take a more directive view

1 towards things and again, back to FCS where there
2 was a decision of we're going to move fixed uses
3 above 3 gigahertz and that that was in everybody's
4 interest to do to make room for this new service
5 and the economic interest of those licensees were
6 taken care of, the costs were paid, so it was a
7 transaction that worked for them as well as for the
8 new licensees. I think we're seeing that model
9 applied. The recent Martin Cave report on making
10 available 3G spectrum that will, where the
11 incumbent will be reimbursed for their costs and
12 for transitioning their systems, I think is a good
13 one to really make that -- make implementation of
14 new services reality while considering the
15 infrastructure costs being imbedded in
16 infrastructure.

17 DR. KOLODZY: Does anyone want to
18 comment on the micro licensing?

19 MR. SIDDALL: Actually, I will. I'm
20 not sure -- if the software-defined radio, assuming
21 as the FCC has been going that the equipment and
22 the software possibilities for it have been
23 approved through the device authorization
24 procedures at the FCC lab, i.e., the spectrum is
25 defined in which it can roam and what its power and

1 antenna gain are, if that's the case, I don't know
2 why you'd need a license and I think if the concept
3 of software-defined radio is followed to its
4 natural end and actually is involved, I think that
5 you will move to more and more unlicensed spectrum
6 structure and there would just be no need for a
7 micro license.

8 DR. KOLODZY: Bruce?

9 DR. FETTE: I'd actually like to
10 amplify a little bit on your concept here. First
11 of all, by saying that one has to recognize that
12 whether you call it micro licensing or cost of
13 spectrum, second-order sharing and so forth, there
14 will need to be an infrastructure to support the
15 hand off and the micro transactions associated with
16 that kind of activity and there's a cost for that
17 infrastructure that would be not unlike the cost of
18 the infrastructure we have today for commercial
19 cellular.

20 So as an alternate, I suggest the
21 concept that we saw in the development of the
22 internet in which the communications infrastructure
23 was essentially a free resource to the development
24 environment with the exception of the cost to the
25 routers that were provided by the government during

1 those early days and that by providing that free
2 infrastructure, significant evolution of technology
3 created a marketplace today and that in a sense
4 similar sense I think that if software-defined
5 technology results in a commons capability, an RF
6 commons capability that we will see that create an
7 interesting and exciting infrastructure in the
8 future.

9 DR. REED: Yes. Let me point out, I do
10 think that micro -- at one point in time I was very
11 interested in this idea of micro licensing, as you
12 call it or the idea that somehow one could clear
13 the rights for different kinds of transmissions,
14 rapidly and efficiently. There's a problem with
15 that. It takes two parts, a technological problem
16 and an economic problem. The technological part is
17 that if we look at the kinds of architectures that
18 lead to the most spectral efficiency, and cellular
19 is kind of a first stage in that, but there's a way
20 to -- a lot farther you can go, the kinds of
21 architectures that support that are what I call
22 cooperative architectures. That doesn't mean
23 friendly cooperative architectures, necessarily,
24 but architectures where, in fact, messages often
25 carried either on multiple hops or through the

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1 cooperation of an infrastructure that understands
2 its interference environment and understands what
3 else -- what the rest of the demand is on the
4 shared medium and negotiates to get all the signals
5 through more efficiently. And you can go to my web
6 page and see a lot of details of those kinds of
7 emerging architectures.

8 Those architectures have enormously
9 better scalability than ones where you have a
10 transmitter transmitting directly to its ultimate
11 receiver. The problem with that in economic terms
12 -- so the micro transactions architecture would
13 have to be much more complicated because it
14 involves not just clearing the right for one
15 transmission, but clearing the right for a whole
16 set of cooperative activities that are competing
17 with a whole set of other cooperative activities.

18 That in economic terms raises the bar.

19 It basically means that if you take the property
20 rights model, every transaction involves not just
21 operating on one person's land, but involves
22 negotiating with nearly everybody in the system.
23 It's what's often referred to as the tragedy of the
24 anti-commons. And the transaction costs tend to go
25 up exponentially in terms of negotiating clearing

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1 to rights when the whole system needs to clear the
2 rights in every round of negotiation. It's not
3 analogous to the stock market. It's just not
4 reasonable to take those architectures and try to
5 map them into peer-wise transactions.

6 So you need a system that self-
7 organizes and does that kind of stuff. Probably
8 won't
9 self-organize around peer-wise transactions
10 efficiently.

11 MR. SNYDER: I have one quick response
12 to that. If the spectrum goes into the existing
13 telecom network, I think you could avoid a lot of
14 the complexity that you're suggesting. I mean it's
15 just that last little section --

16 DR. REED: That's basically a short
17 term solution to a specific problem, but if we're
18 talking about the general problem of enabling all
19 kinds of wireless communications, many of which we
20 can't anticipate, then you're basically optimizing
21 for one thing, last-mile bypass, which we optimized
22 for AM radio. Is that the next thing or should we
23 do a more general job?

24 DR. KOLODZY: Okay, I want to get back
25 to the audience a little bit because there were a

1 lot of questions that were out here a few minutes
2 ago and I don't want to pass that -- Dave, do you
3 want to make a quick comment?

4 DR. FARBER: Yes, just quick comment.
5 I feel obliged to repeat something I said earlier,
6 that one of the issues in the future is going to be
7 security and I don't mean this just in the national
8 defense issue. The spectrum is going to be used
9 for a lot of applications, most of which we don't
10 understand now, but some of them are going to be
11 critical applications to at least the individual.
12 And unless we design the security into those
13 systems, especially software-based systems, we're
14 going to be in deep, deep trouble, even if our
15 spectrum space is available, so I think we have to
16 pound on that and it's not something that my
17 experience at the FCC says that they worry about
18 all that much.

19 MR. STROH: My name is Steve Stroh.
20 I'm editor of "Focus on Broadband Wireless Internet
21 Access." And one of the things that Chairman
22 Powell said this morning really struck me. He
23 would really like to hear concrete proposals for
24 how we get to the ideal of more of a spectrum
25 commons model, flexible use and away from the

1 private ownership model.

2 One thing that strikes me is that Mr.
3 Tawil stated that they had gone down to using 288
4 megahertz of TV spectrum and what frustrates a lot
5 of the techies and I've watched the 2.4 gigahertz
6 thing band evolve very incredibly, long-range, very
7 high bandwidth, many users, very dense deployments.

8 They're making all that work in 83 megahertz of
9 spectrum with some really onerous rules like very
10 low power and they're making it work in that little
11 chunk of spectrum in a very bad part of the
12 spectrum for things like tree foliage.

13 The TV broadcasters have a total of 288
14 megahertz of spectrum available in the prime part
15 of the spectrum and yet in any market, there's a
16 handful of those channels that at most that are in
17 use, 20. I'll be charitable and say 30. Why not
18 evolve a model that lets a radio use the channels
19 that are not being used for broadcasting and the
20 radio has got to have a very specific limitation
21 that it listens on a particular channel and if it
22 hears TV broadcasting it just positively locks that
23 up. There's no possibility of override. The radio
24 just cannot go there if it hears a TV broadcast.

25 But the 75 percent of the other

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1 channels that aren't in use, that's legal, and it
2 listens on a periodic basis every 10 minutes and
3 that will encompass the ability to hear low powered
4 TV stations, even somebody who's using one of these
5 little rabbit transmitters that transmit on Channel
6 3 or 4 inside a house, it wouldn't interfere with
7 those. That's a way to get -- that's a way to at
8 least start the transition into a more flexible use
9 model. It's frustrating to hear the idea that that
10 broadcast spectrum can't go there, no way, no how.

11 MR. TAWIL: Let me answer that one. In
12 fact, I didn't say that. I think we're limited
13 obviously if you use less spectrum, we will. But
14 there is something called the legacy issue. It's
15 something called a television receiver, you have in
16 your home that when you use your idea, even though
17 I'm transmitting on my 6 megahertz channel and
18 giving you that service, that TV set receives all
19 signal and guess what, when you put that low
20 transmitter or even if you have five channels, it
21 disrupts that TV set. So the issue is not actually
22 the transmission, it's the reception and for the
23 past 40 years there are no attempt to actually deal
24 with the receiving component of it.

25 MR. STROH: Wasn't the decision just

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1 yesterday in five years the TV receivers will be
2 required to receive digital and if it's not a
3 digital TV transmission, it simply won't be
4 displayed?

5 MR. TAWIL: That is correct, but guess
6 what, they still haven't decided on what the
7 receiver performance is or what the interference
8 is. It's still the same TV set. You still have
9 the same interference immunity with that spectrum
10 that you have in the analog world.

11 MR. STROH: If an interference is being
12 encountered, isn't that incentive for the TV owner
13 to go buy a new one? If you're interfering with --

14 (Laughter.)

15 MR. TAWIL: I'd love them to buy a TV
16 set that actually operates only on the 6 megahertz
17 it transmits and doesn't -- and leave the other
18 spectrum for other use, but it's not. The issue
19 here is the chicken and egg issue. You're trying
20 to be on the transmitting -- interference occurs
21 two ways. It occurs because the transmitter is
22 spreading spectrum outside its band or the receiver
23 is not selective enough to deal with the
24 interference.

25 If you only deal with one end of it,

1 there's no way you're going to get there. You have
2 to deal with both ends of it to be able --
3 broadcasters are not against more efficient use of
4 the spectrum. Broadcasters are not against
5 flexibility. What they're against is having --
6 against disrupting the service and they don't have
7 control over it. That's what they do.

8 It's something that you would like to
9 move forward and we can go up there. It's an open
10 system. We can't go up there and buy a TV set and
11 give it to the consumer and make sure that it works
12 properly and it's interference-free. That has to
13 be done from the consumer end.

14 DR. KOLODZY: Bruce?

15 DR. FETTE: I'd like to observe that
16 again on the subject of software-defined radio, if
17 you recognize that it's conceivable to define wave
18 forms which are sufficiently orthogonal to the
19 video and audio tracks of TV channels that you can
20 define a wave form that is sufficiently orthogonal,
21 that it will not interfere, even with TV sets that
22 have moderately poor design of the RF front end and
23 mixers. In fact, that's a subject of research at
24 this time as to how multiple types of wave forms
25 can be designed which are sufficiently orthogonal

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1 to each other to provide essentially overlapping
2 spectral utilization without interfering with each
3 other.

4 MR. SIDDALL: I want to address the
5 broadcast issue just briefly, because I think
6 there's a little misunderstanding of what the FCC
7 rules and the statute provides for today.

8 First of all, TV spectrum is already
9 shared. There are millions of medical devices and
10 hospitals all over the country that are on TV
11 channels, as a matter of fact.

12 Second of all, there's public safety
13 services in 13 cities around the country that also
14 use certain TV channels, but I'm not here to defend
15 broadcasting at all. But I do think it's important
16 to understand it is in a transition to digital.
17 When that transition is over, there are no more UHF
18 tabus. The digital transmission system has been
19 designed to allow the use of adjacent channels and
20 when the analog turn off, at least when I left the
21 Commission, the intent was that there would be
22 decisions on whether the interstitial channels
23 would be auctioned for broadcast use or for other
24 uses. But we're in the middle of that transition
25 now. And I think that that is recognized. The

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1 more important public policy issue that is involved
2 is to what extent will the statutory provisions
3 allowing broadcasters flexibility will be
4 implemented. In 1997, Congress amended the Act and
5 provided that broadcasters transmitting a digital
6 signal need only provide one video channel.
7 Otherwise, they have flexibility to provide
8 anything they want within -- that can be provided
9 using that digital system. It's subject to a fee
10 if it's a subscriber based service.

11 The question is will broadcasters move
12 to that model and use that excess capacity of the
13 digital for other services or is there no excess
14 because the demand and the economic model dictates
15 that they provide high definition which requires
16 more bit rate. They can even provide two high
17 definition channels, signals within the 6 megahertz
18 actually through compression techniques and it will
19 probably be 4 in five years the way compression is
20 working. And Congress already answered the
21 question about broadcaster flexibility. So what
22 you see today, don't assume that that is tomorrow.

23 That's been addressed and I think that needs some
24 time to work out.

25 The other -- because I think there is a

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1 lot of flexibility built in there for a lot more
2 spectrum efficiency. That was one of the things
3 really addressed and I hope to see that. I just
4 want to put that on the table. The one last
5 comment, because maybe being the second person in
6 this room that has ever put a wire on a receiver
7 from 0 to 2 gigahertz and looked at what's there, I
8 can tell you, I can give you two different results.

9 I can do that right here in this room. You will
10 find 95 percent of the spectrum unused.

11 I can go up to the roof of this
12 building, connect to that log periodic antenna that
13 the Comm's Room uses here at the FCC. And in fact,
14 there is one of these receivers in the Comm's Room
15 right here in the building for those FCC staff that
16 want to look at it and I will show you very heavy
17 spectrum use through most of the spectrum. It
18 depends where you do it and it can be very
19 deceiving these little things.

20 In cities is where the problem -- I
21 think from a policy standpoint, the better issue to
22 address, the more important issue is rural versus
23 urban. In urban areas when I put a receiver on a
24 decent gain antenna, there's a lot of usage. When
25 I go out into rural areas there's almost no usage

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1 and to the extent that services are required in
2 rural areas, I think there is a policy issue about
3 trying to make one size fit all.

4 I was out with some of the FCC folks in
5 Arizona back a couple of years ago and they were
6 talking about bringing cellular service and they
7 laughed because I said look, there's a lot of
8 surplus analog cellular systems out here. You guys
9 don't have phones. Get some of the surplus analog
10 stuff, stick it out here. Yeah, it's a spectrum
11 hog, but spectrum -- you've got all the spectrum
12 you could possibly need. It would actually be a
13 very good thing to do and very cheap to bring phone
14 service all around here. You don't need the
15 digital services to start with perhaps. One size
16 doesn't fit all and I go back to what I said at the
17 beginning. I hoped that the recommendations of the
18 policy force -- policy task force will recognize
19 that in different areas of the country, different
20 policies should apply and for different services,
21 different policies should provide. I'm sorry, but
22 I had to try to set the record straight on what the
23 digital rules are since I was here and had quite a
24 bit to do with them along with a lot of other
25 people sitting in this room.

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1 MR. VAN WAZER: Hi, my name is Tom Van
2 Wazer. I work at a private law firm. Following up
3 on what David said, one of the problems about the
4 spectrum flexibility that does exist for digital
5 broadcasters is I don't even think Congress
6 understands that there's digital flexibility. If
7 you've read anything in the last two years about
8 some of the networks' plans to develop their
9 digital spectrum, any time any one has suggested
10 that they're going to do something other than
11 broadcast pictures, they've been punished one way
12 or another, either by Congress or by others. And
13 maybe one of the major contributions of this task
14 force would be to recognize that flexibility needs
15 to be something that the Commission embraces
16 everywhere and not make it such a terrible thing to
17 even think about because if you want companies to
18 invest in more efficient distributed transmissions
19 or single frequency networks, etcetera, you need to
20 have incentive to do so and you can't -- the
21 spectrum that's currently allocated to these
22 companies, not just broadcasters, needs to be --
23 they have to have some incentive to do so and so
24 flexibility has to be recognized.

25 The only other point, I've been

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1 interested in watching the debate between Mr. Reed
2 and or the debate or the points that Mr. Farber and
3 Mr. Reed have made versus others about property
4 rights and following up what David said, how he was
5 lamenting the loss of all these research labs and
6 how everyone is sort of failing to invest in
7 research labs like they were, it seems to me that
8 that's an outgrowth of this what I view at least
9 academic view of the commons that's unlimited,
10 where the sheep bring their own grass. The problem
11 is there isn't a sufficient incentive for the
12 companies to invest in these research labs to
13 develop the technology that you're interested in.
14 So I'd like to hear your comment.

15 DR. REED: Actually, I'll make a quick
16 comment since you addressed it to me.

17 The return on the kinds of research
18 that I'm talking about is a rich and vigorous
19 equipment market that would -- and what you might
20 call software tools and protocols. What is going
21 on and it's sort of exemplified by the experience
22 of Interval Research which got started on ultra-
23 wide band back in 1993 or 1994, and participated by
24 funding a whole lot of policy activity here at the
25 FCC to try to get ultra-wide band addressed,

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1 Interval also spun off a company, Phantasma
2 Networks which developed a lot of that early
3 technology. That company was put out of business
4 because its investors finally said you know, we
5 just can't wait any more. We can't wait for the
6 flexibility. We're just going to sell off the
7 assets and so a lot of good people went. The
8 assets were ultimately bought by a company called
9 Xtreme Spectrum so we may see some of that value at
10 some point, but in fact, the investment market is
11 not about spectrum. I really think that's
12 important to make. The investment return --
13 because someone can hold spectrum and make money on
14 it without ever doing anything unless the FCC takes
15 it away from them. The investment is in the new
16 technology and the pay off is in the equipment.

17 DR. RITTENHOUSE: I would like to also
18 make a comment on research in general and in
19 particular, the industrial labs. Research
20 continues in the industrial labs, particularly in
21 these types of areas because of the popularity of
22 wireless technologies and trying to investigate, it
23 is done in collaboration now which I think is a
24 very positive thing with a lot of academic labs as
25 well. So instead of expanding a lot of the labs

1 and the research in the labs, to the extent that it
2 can collaborate with other labs and academics is a
3 very good thing. So we do get a lot of that
4 sampling now through the collaboration as well.

5 MR. PITTSCH: I wanted to jump and sort
6 of give a spin on your question which is that I
7 think these two approaches, concrete rulemakings,
8 looking at creating noninterfering easements and
9 more commons, 5 gigahertz and so on, and also
10 creating a simultaneous exchange, are complementary
11 for two reasons. One, I've heard some people say
12 well, from the commons side well, we can't do that.

13 That will entrench people and so on. The kind of
14 thing we're talking about, incumbents have got the
15 stuff already, right? And just do a little thought
16 experiment. Imagine your most hide-bound spectrum
17 holder. Don't say names out loud or anything, but
18 now ask yourself will they will be more hide-bound
19 and more inflexible if you give them flexibility or
20 if you keep them the way they are? Okay?

21 The second point I'd make is that if we
22 move forward on both fronts, on the market-base
23 side we're going to facilitate aggregation,
24 relocation and so on. That's going to make it
25 possible for some of these market-based solutions

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1 for the new technologies that people are talking
2 about.

3 The third point is huge which is that
4 any reduction in scarcity helps both approaches.
5 If the commons approach reduces scarcity, then it
6 becomes easier and the incumbents have less reason
7 to oppose market-base reforms and vice versa and I
8 already suggested that there's a potential benefit
9 to new technologies because if you bet your whole
10 wad on noninterfering easements or commons
11 approach, you may be foreclosing in terms of time
12 and efficient result some opportunities that could
13 be pursued on the market front.

14 DR. KOLODZY: That was one heck of a
15 question.

16 (Laughter.)

17 DR. FARBER: Well, can I?

18 MS. RATH: Go ahead.

19 DR. FARBER: I was stuttering and
20 sputtering, etcetera with the comment that people
21 don't invest in research because structural,
22 whatever it was. My experience is a lot of
23 companies don't invest in research because it's
24 deferrable and when things are tight, they defer
25 right off the end.

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1 The telecommunications industry has
2 done this, not all places, but large numbers of
3 them but I point out just endlessly, that there are
4 companies who see a future and maybe it's the
5 environment they live in, maybe it's other things,
6 but look at DoCoMo which has almost doubled the
7 size of their research lab over the next year. The
8 question is, to use military terms, 6.1., 6.2, or
9 6.3 money is still a question, but the only way
10 you're going to move this field is to do the
11 investment now in basic research which will pay off
12 in 5, 6, 7 years. It's not going to pay off
13 tomorrow, but if you don't do it, it certainly
14 isn't going to pay off.

15 DR. RITTENHOUSE: Fortunately, there
16 are some companies that remain that continue to do
17 the basic research, right.

18 MS. RATH: Actually, one question I had
19 is as I listen to all this, as an industry, is the
20 wireless industry underperforming in terms of its
21 research, development and technological innovation
22 as compared to other industries?

23 DR. FARBER: My own view from some
24 experience, I should give a little bit of
25 experience, I was on AT&T's advisory board for a